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OUT-OF-BODY-LIKE EXPERIENCES ARE MORE PROBABLE IN PEOPLE WITH ELEVATED COMPLEX PARTIAL EPILEPTIC-LIKE SIGNS DURING PERIODS OF ENHANCED GEOMAGNETIC ACTIVITY: A NONLINEAR EFFECT [1]

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Summary.—The ratings of subjective experiences of the self "leaving" or of being detached from the body were obtained (over a 3-yr. period) for a total of 128 men and women who had been exposed only once to an experimental setting which enhances the awareness of cognitive processes. As hypothesized, the individuals who exhibited the greatest proportion of complex partial epileptic-like signs also reported the most intense experiences of detachment from the body; however, these occurred primarily when the geomagnetic activity on the day of the experiment exceeded about 15 nT but was less than about 45 nT. Geomagnetic activity for the day after or the three days before the experiment was not associated with these experiences. The effect was equivalent to a correlation coefficient (*eta*) of .38.

The fundamental principle of neurophenomenology is that all subjective experiences, despite their apparent cultural or religious implications, are associated with specific patterns of brain activity. One common experience is that awareness is egocentric or localized within the body. Depersonalization, detachment, and out-of-body sensations can be interpreted as episodes when the sense of self is perceived as spatially or phenomenologically different from the person's three-dimensional structure. The prevalence of these experiences within the human brain can be argued to be the phenomenological basis for this species' "common-sense" belief and philosophical conviction of mind-body dualism.

The experiences of cognitive diplopia, whose cross-cultural labels vary from Döppelganger to tulpa, have been associated with alterations in the functional organization of the temporoparietal lobes. They can range from chronic changes in neuronal density due to brain injury (Critchley, 1953) to more subtle asymmetric alphoid activity over the parietotemporal regions (Tart, 1967). These mind-body experiences are moderately correlated with the persons' scores for complex partial epileptic-like signs (Persinger, Koren, Makarec, Richards, & Youlton, 1991).

The model of vectorial hemisphericity (Persinger, 1993) predicts that experiential diplopia emerges during (primarily transient) conditions which

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encourage unusual intercalation between the left and right temporoparietal lobes. Some periods of rapid eye movement (REM) sleep, during which dreaming is reported, are associated with the common experience of the self both observing the scene from within the body and being detached from the body. The dynamic process which precipitates the necessary intercalation is assumed to be activated by microseizures originating within the mesiobasal portions (hippocampal-amygdaloid) of the temporal lobes. These regions exhibit the lowest electrical thresholds of the brain and appear to be particularly vulnerable to the alterations in the concentrations of the endogenous anticonvulsant: melatonin (Persinger, in press). This serotonin-derivative is remarkably sensitive to very weak (nanoT to microT) time-varying magnetic fields (Jacobson, 1994) when their vectorial structure is a rotating (circular) toroid (Kato, Homma, Shigemitsu, & Shiga, 1994). The three-dimensional structure of geomagnetic activity exhibits this geometry (Campbell, 1967).

Several researchers have reported a decrease in the threshold of electrical seizure activity (as inferred by the increased incidence of the temporal lobe epileptic syndrome) during periods of enhanced geomagnetic activity (Keshavan, Gangadahr, Gautman, Ajit, & Kapur, 1981; Rajaram & Mitra, 1981). If increased geomagnetic activity encourages either neuroelectrical lability or alterations in interhemispheric coherence and these alterations are also reliably reflected in a person's score for complex partial epileptic-like signs, then experiences of detachment during enhanced geomagnetic activity should occur primarily for nonepileptic individuals who exhibit elevated indicators of temporal lobe lability. This experiment and analysis were designed to test this hypothesis.

Method

A total of 128 men and women were exposed singly to a partially deprived sensory setting during the years 1989, 1990, and 1991. During the single 30-min. exposure, weak (1 microTesla) experimental magnetic fields were applied to the left, right, or both hemispheres while the subject sat in a comfortable chair within an acoustic chamber (e.g., see Richards, Koren, & Persinger, 1992; Richards, Persinger, & Koren, 1993). The subject's eyes were covered by opaque goggles; the only light was from a dim red photography bulb (<1 lux). At the end of the session, the subject completed an Exit Questionnaire of 20 items. Possible scores for each item were 0 (did not occur), 1 (occurred occasionally or at least once), and 2 (occurred frequently).

For this experiment Items 6 ("I felt as if I had left my body or was detached from my body") and 15 ("I felt as if I were somewhere else") were selected. The former was the target experience while the response to Item 15 served as a control for a similar experience ("nonspecific effect") that did

not involve the sense of self-detachment. To control for baseline differences in the propensity to report experiences generally, the proportion scores for detachment experiences was determined by dividing this raw score for that item by the mean score for all 20 items of the Exit Questionnaire. The inference for complex partial epileptic-like experiences was each person's score (proportion of endorsed items) for this cluster of 16 items from the Personal Philosophy Inventory (Persinger & Makarec, 1987, 1993). The validity and reliability parameters for this inventory have been reported elsewhere (Persinger & Makarec, 1987, 1993). The inventory was given within a different (class) setting about two weeks to two months before the experiment.

Measurements of global geomagnetic activity were obtained from the monthly issues of the *Geomagnetic Indices Bulletin* [National Geophysical Data Center, Solar-Terrestrial Physics Division (E/GC2), 325 Broadway, Boulder, Colorado, 80303]. The mean daily aa (antipodal index) activity, measured in nanoTesla (nT), for global geomagnetic activity was obtained for the day of the experiment, the day after the experiment, and for each of the three days before the experiment. On the bases of the results with these measures, the 3-hr. Kp (planetary K) indices (which are progressive integers between 0 and 9 that are quasilog representations of absolute variations in geomagnetic intensity) for the period and for each of the two 3-hr. periods before and after the periods within which the experiments occurred (local time ranged between 1300 hr. and 2200 hr.) and for the six successive 3-hr. intervals (0000 hr. to 0300 hr., UT on the day of the experiment or approximately 2000 hr. to 2300 hr. local time) were obtained.

Converging evidence (Edelman, 1989; John, 1990) suggests that one solution to the intricate relationship between the sense of self and the general process of human consciousness may involve subtle, complex processes within relatively narrow bands of neuronal activation and organization (nonlinearity). If this assumption is valid, then (1) the information content of the stimulus rather than the intensity (above the critical threshold) of the signal may be the significant determinant and (2) any effects from the biorelevant stimuli associated with global geomagnetic activity should be nonlinear. They would be masked by traditional linear models such as Pearson or Spearman correlation coefficients.

If there is a reliable but nonlinear association between subtle neurocognitive processes such as the sense of self or consciousness and both endogenous (complex partial epileptic-like signs) and exogenous (geomagnetic activity) relationships, then analysis of variance would be the appropriate tool for examination. Until recently, there have been no *a priori* empirical or theoretical criteria to select the increments of geomagnetic activity that would optimally reveal any recondite relationship. Now several correlational analyses (Bureau & Persinger, 1992; Randall & Randall, 1991; also see Semm,

1988, for discussion) have shown associations between enhanced geomagnetic activity and neurobehavioral phenomena whose occurrence are commensurate with transient disruption of homeostasis (Persinger, 1988) within limbic-neuropeptide (probably CRF, i.e., corticotrophin releasing factor) systems, occur when the daily geomagnetic activity exceeds about 20 nT.

For the present experiment the average geomagnetic activity on the day of the experiences was divided into four increments (0 through 15 nT, 16 nT through 30 nT, 31 nT through 45 nT and >45 nT). The second (neurocognitive) variable was trichotomous and reflected the subjects' scores for complex partial epileptic-like signs (lowest one-third = 0 through 19%, middle one-third =20% through 31%, and upper one-third = 32% to 100%). There were between 9 and 18 subjects for each of the resultant 12 groups (four increments of geomagnetic activity × three groups of temporal lobe sensitivity). Chi-squared analyses ($\chi_{11}^2 = 10.11$) indicated no significant ($p > .05$) disparity in distribution of the numbers of subjects between the groups. The means and standard deviations for experiences of self-detachment from the body are shown in Table 1. All analyses involved SPSS software on a VAX 4000 computer.

Results and Discussion

Analysis of variance yielded a statistically significant ($F_{6,116} = 3.17$, $p < .001$; approximate $eta = .38$) interaction between complex partial epileptic-like signs of the subjects and the geomagnetic activity during the day of the experiments for the incidence of the out-of-body-like experiences. This interaction was not significant for each of the three days before or the day after the experiment (all $Fs < 1.00$). The main effects for geomagnetic activity were not (all $F_{3,116}s < 1.00$) statistically significant for the experimental day or the other days. Subjects whose histories reflected the most numbers (upper one-third of group) of complex partial epileptic-like signs reported significantly more intense and more frequent detached experiences (all $F_{2,116}s$ about 8.10, $p < .001$; approximate $eta = .37$) than subjects from the other two groups who reported less frequent complex partial epileptic-like signs.

TABLE 1

Rating of Intensity of Sensations of "Detachment" or the "Self Leaving the Body" Within the Experimental Chamber, the Daily Geomagnetic Activity (Increments of 15 nT) and Subjects' History of Complex Partial Epileptic-like Signs

Complex Partial Epileptic-like Signs	aa activity (in nT or gamma)							
	0–15		16–30		31–45		>46	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Lower One-third	0.0	0.0	0.3	0.5[a]	0.2	0.6[a]	0.5	0.8
Middle One-third	0.7	0.8	0.2	0.4	0.4	0.7	0.4	0.6
Upper One-third	0.7	0.9	1.2	0.9[b]	1.1	0.8[b]	0.4	0.5

[a] vs [b] $p < .05$.

Post hoc analyses (Tukey, set at $p < .05$) indicated that the greatest subjective intensity of out-of-body-like experiences was reported primarily for those subjects who exhibited the strongest complex partial epileptic-like signs on those days when the ambient geomagnetic activity ranged between 16 nT and 45 nT. The interaction between the geomagnetic activity only on the day of experiments and the subjects' indicators of temporal lobe lability was also significant statistically ($F_{6,116} = 2.86$, $p < .05$; $eta = .36$) for the *relative* incidence (proportion scores) of detached experiences. Because one of the cells contained no variance and to control for the occurrence vs the nonoccurrence of the out-of-body experience, loglinear (hierarchical) analysis was completed as a function of this measure and the person's increment of temporal lobe lability and the increment of geomagnetic activity on the day of the experiment. A statistically significant (partial $\chi_6^2 = 17.42$, $p < .01$; $phi = 0.47$) three-way interaction was found *Post hoc* comparisons verified the source was similar to that found by the analysis of variance (cf. superscripts in Table 1).

Neither the mean total numbers of experiences nor the experience of being somewhere else exhibited either significant geomagnetic effects ($Fs < 1.00$) or the statistically significant interaction with the complex partial epileptic-like signs; however, both of these subjective indices were significantly higher ($Fs = 8.76$ and 5.23; $etas = .35$ and $.28$, respectively) for the group who reported the most frequent historical incidence of complex partial epileptic-like signs. The means (and standard deviations) for the three successive groups of elevated complex partial signs were 0.5 (0.2), 0.6 (0.2), and 0.7 (0.3), respectively, for the mean of the total number of experiences and 0.7 (0.8), 0.9 (0.8), and 1.2 (0.8), respectively, for the experience of being somewhere else.

To discern if there were any specific increments of time within which the magnitude of geomagnetic activity contributed maximally to the interaction between complex partial epileptic-like signs and the experiences of detachment within the experimental chamber, the 3-hr. incremental (Kp) values (0, 1 were collapsed to 1, and 5 or greater was collapsed into intensity five; elsewise the values were maintained) for each of the four successive periods before, for the period during, and for the period after the time of the subjects' experiences were evaluated. Results indicated that the critical component was not the lag time before the individual's experimental period (which ranged between 1300 hr. and 2200 hr. local time); the real (local) time was critical. The only statistically significant interactions between complex partial epileptic-like signs and geomagnetic activity occurred for the interval between international time 0300 hr. and 0600 hr. ($F = 2.04$) and 0600 hr. and 0900 hr. ($F = 2.19$); this period corresponded to between approximately 2300 hr. and 0400 hr. of the late night and the early morning before

the experiment. None of the other six 3-hr. increments for the day were significant statistically ($Fs < 1.00$).

The results of this study support the hypothesis that sensitivity or lability of portions of the brain which are most correlated with the reports of complex partial epileptic-like experiences are sensitive to a component of geomagnetic activity when it is above a specific "threshold" but not during extreme perturbations, i.e., a window effect. Although the possibility of nonlinear intensity effects must be considered (Adey, 1975), the aa indices are crude measures of amplitude and may not reflect the causal variables. The likelihood that there is some particular frequency or pattern of information which is probabilistically associated with this range of intensity variation in global geomagnetic activity must be considered.

The concurrence between daily geomagnetic activity and the enhanced experiences of detachment of the self from the body for individuals whose brains are more prone to generate these experiences meets the criteria, superficially at least, of temporal concurrence. However, the actual increment of time which was significantly associated with these experiences within the experimental setting had occurred more than 12 hours previously. That the strongest effect between the intensity of detachment of the sense of self from the body and geomagnetic activity occurred for this measure during the late evening before and the early morning of the day of the experiment suggests that the effects of these environmental perturbations may be significant for at least 24 hours. Because most of our subjects would have begun their nocturnal activities, particularly sleep, during these periods the possibility that disruption of the initial stages of sleep generated changes which were simply exacerbated or amplified the next day when the subject was placed in the experimental setting can be considered a palatable hypothesis.

We have assumed that the sense of self (Persinger, 1993) is a complex subtle process whose occurrence involves a quantitative matrix of electrical patterns within the range of electroencephalography; these magnitudes are about 1% of the steady state (d.c.) electrical potential within cerebral space. A more exploratory hypothesis is that the neurocognitive processes which are associated with the generation of the sense of self are coherent or intercalated with some unspecified feature of the steady-state or quiet component (< 15 nT) of the geomagnetic field. During periods of perturbation (increased geomagnetic activity) which involve magnitude variations of about 1% of the steady-state component of the field (Persinger, 1980), this coherence is disrupted. The sense of self can then be discriminated as different or detached from the body schema.

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